

Radiation Damage to the CDF Silicon Detectors

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All Experimenters Meeting

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Silicon Detector Lifetime

Silicon detector lifetime is a complex issue involving

- ▶ beam incidents
- ▶ long-term radiation damage
- ▶ component failures

Silicon Detector Lifetime

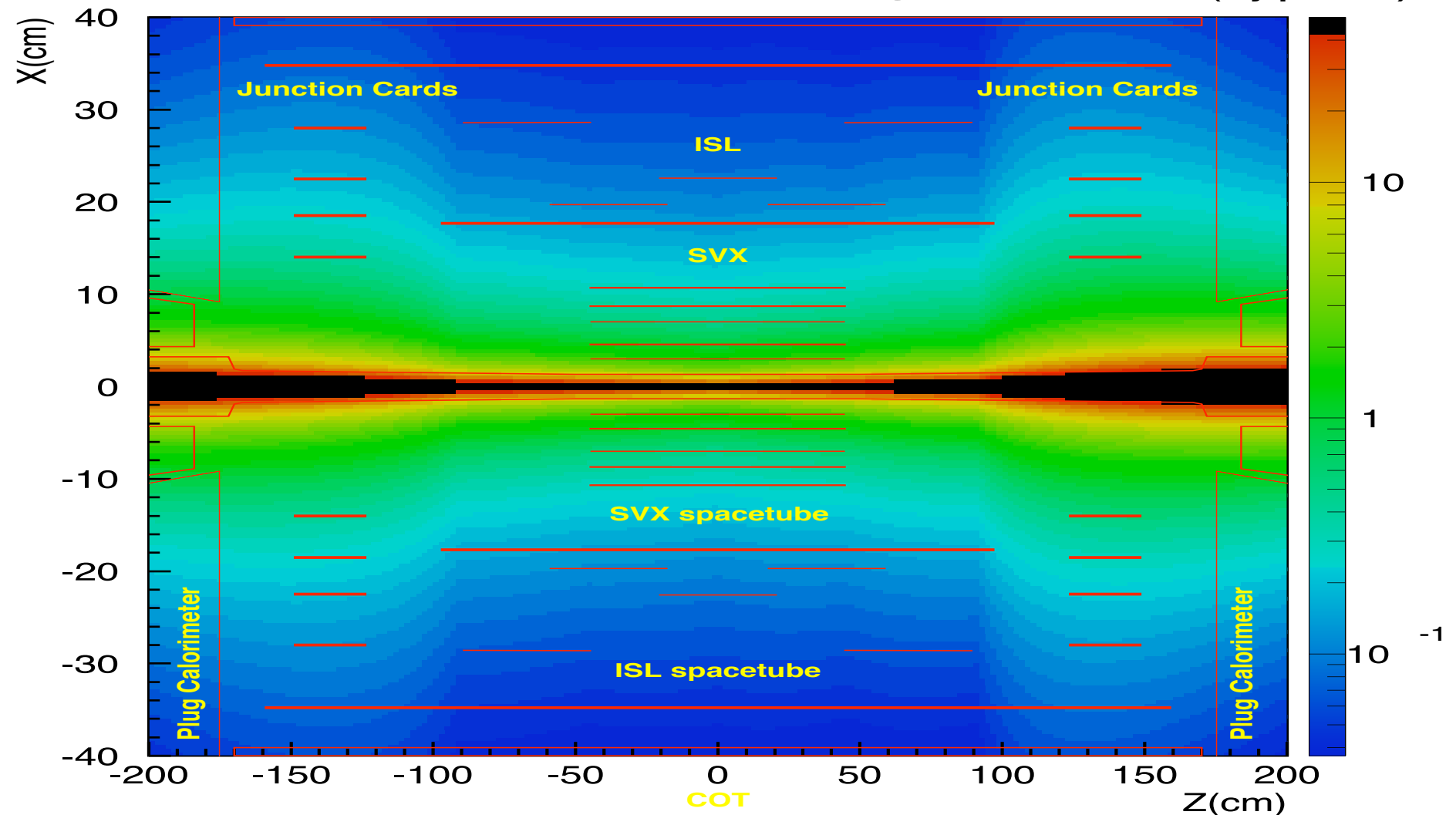
At CDF, the lifetime of our silicon detector is studied by two groups

- ▶ The Radiation Monitoring Group
 - Radiation and beam-related effects
 - TLD's, Bonner spheres, pin diodes, diamond, active dosimeters (with CERN), and the silicon detector itself
- ▶ The Silicon Operations Group

Dose in the Tracking Volume

over 90%
of the total
radiation is
due to
collisions

collisional component of ionizing radiation γ Dose (Gy/pbarn⁻¹)



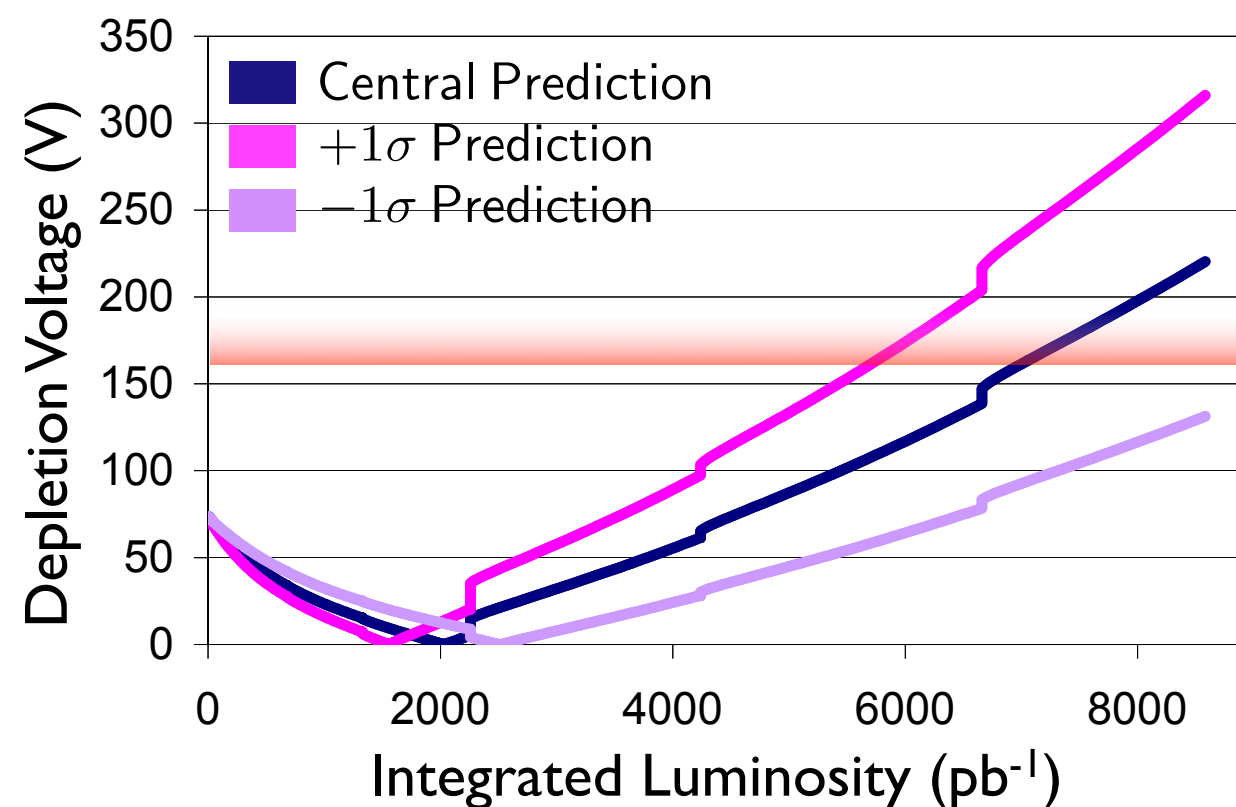
R.J. Tesarek, et. al., *A Measurement of the Radiation Environment in the CDF Tracking Volume*, Nucl. Inst. & Meth. A514 188-193, 2003

<http://ncdf67.fnal.gov/~tesarek/radiation>

Depletion Voltage

- ▶ Our silicon must be depleted or it is useless
- ▶ The required bias voltage evolves under irradiation
- ▶ Our detector has a **maximum bias voltage**
 - capacitively-coupled readout
- ▶ Possible end of usefulness
- ▶ Our predictions have large uncertainties
 - ➡ monitor the depletion voltage

Innermost Layer of SVX



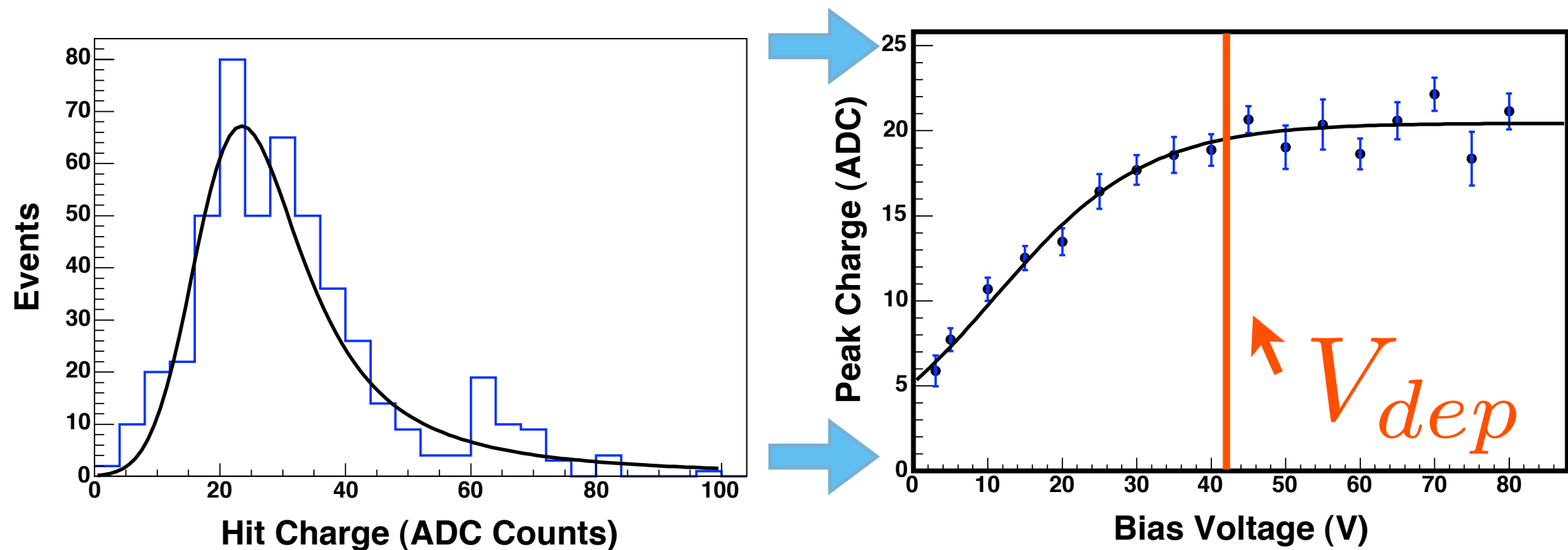
S. Worm, "Lifetime of the CDF Run II Silicon," VERTEX 2003

Depletion Voltage Measurement

We use two methods to monitor depletion voltage

- ▶ signal vs bias scan
- ▶ noise vs bias scan

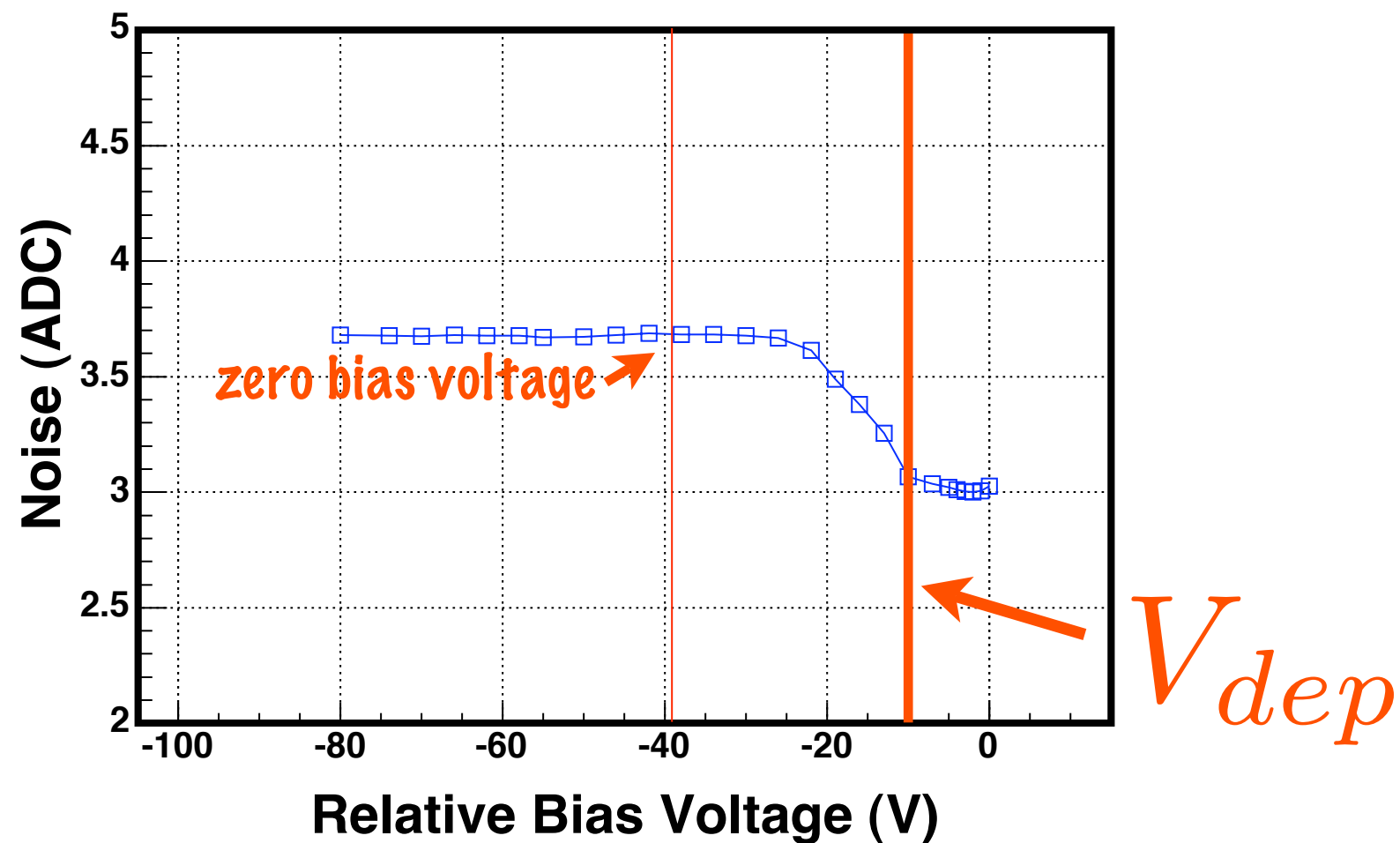
Signal vs Bias Method



Signal vs bias scan

- ▶ study collected charge (hits on tracks)
- ▶ vary bias voltage while colliding beams

Noise vs Bias Method

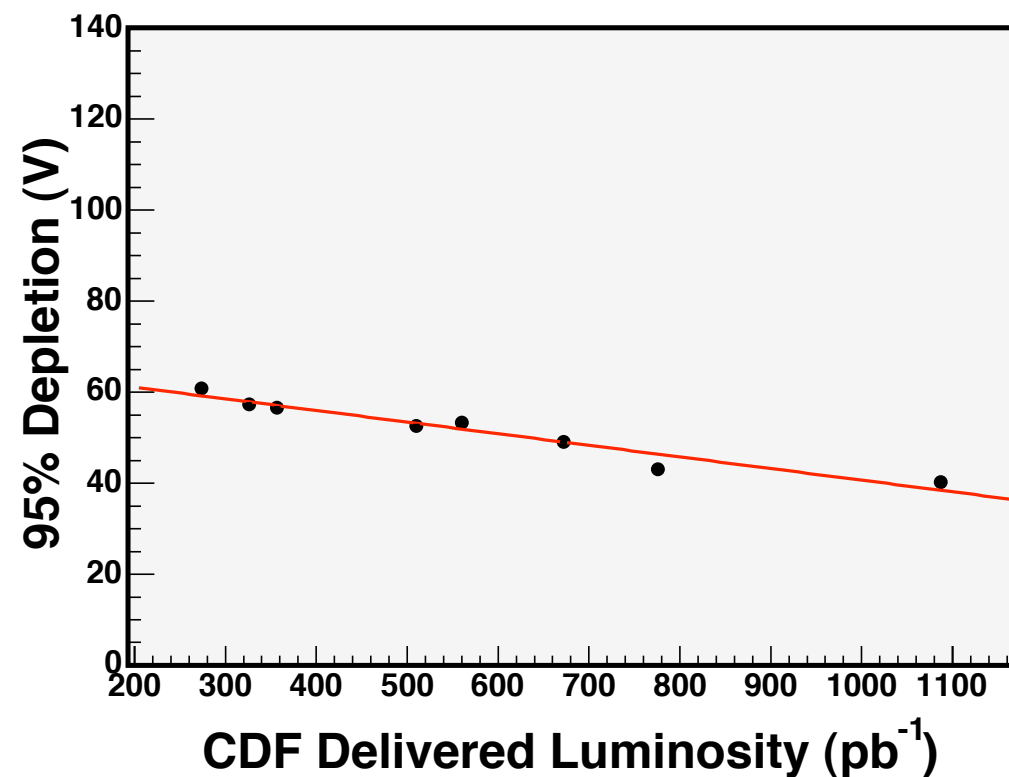


Noise vs bias scan

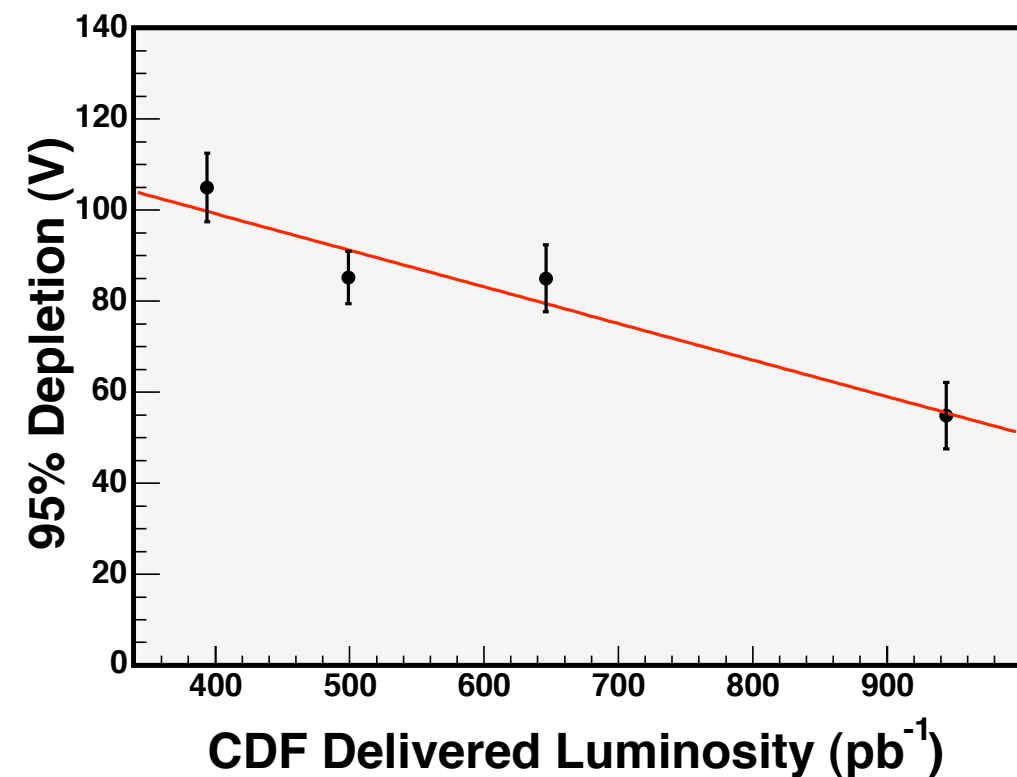
- ▶ study mean noise
- ▶ vary bias voltage during quiet time

Depletion Voltage Evolution

SVX Ladder From Innermost Layer

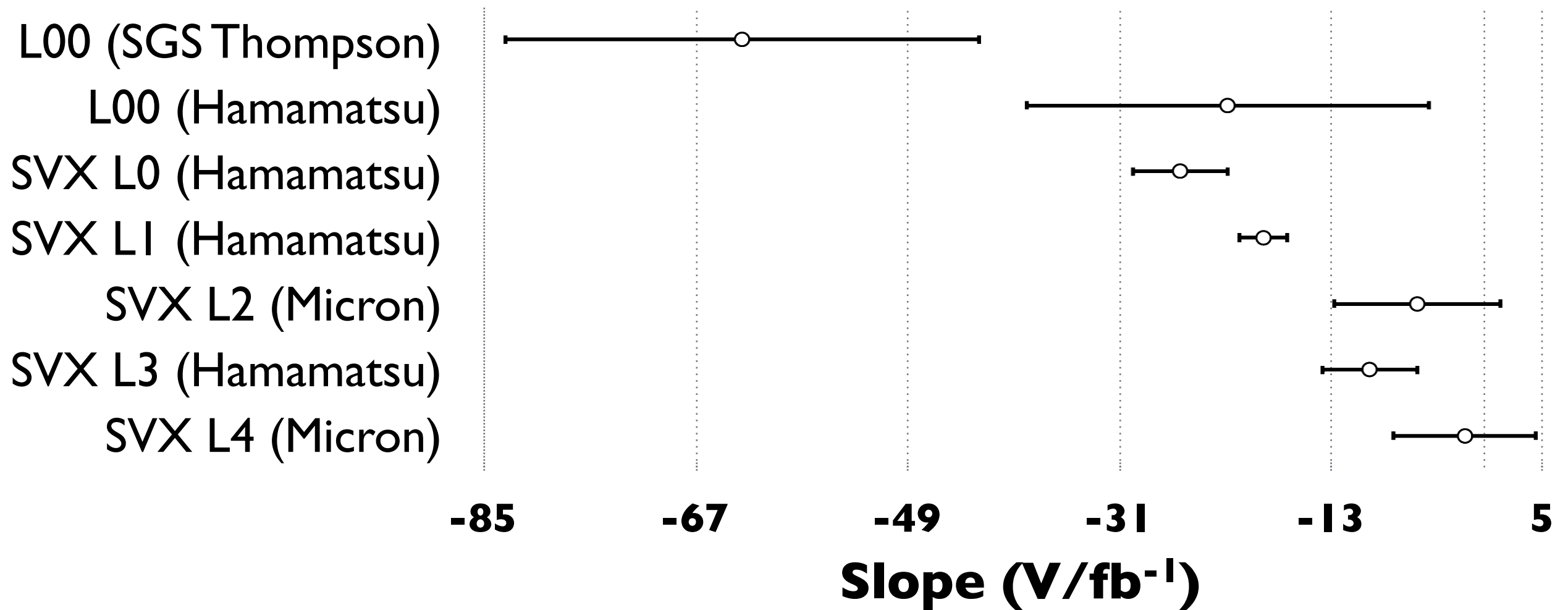


L00 Ladder From Innermost Layer



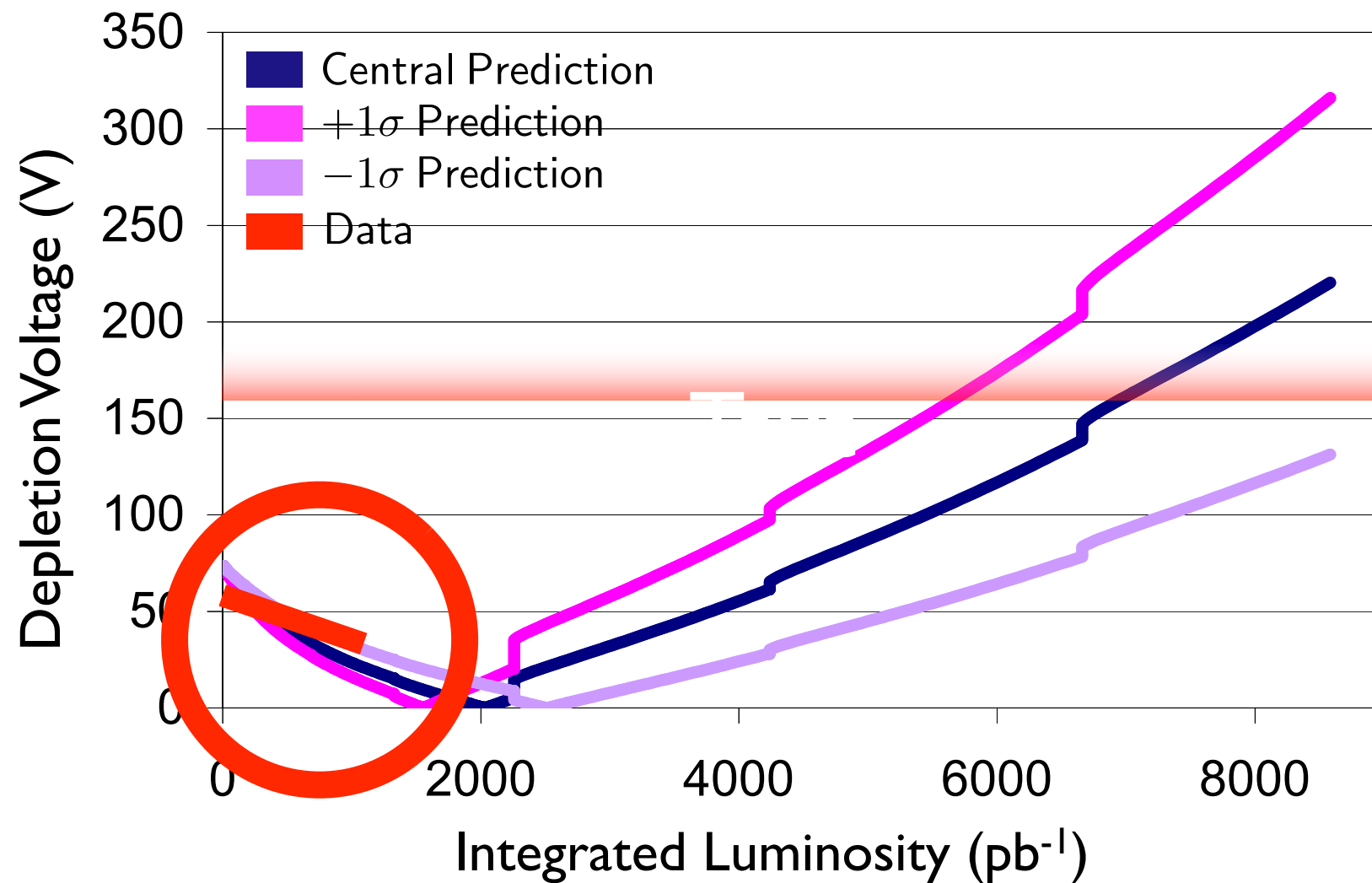
We repeat these scans as luminosity accumulates...

Depletion Voltage Evolution



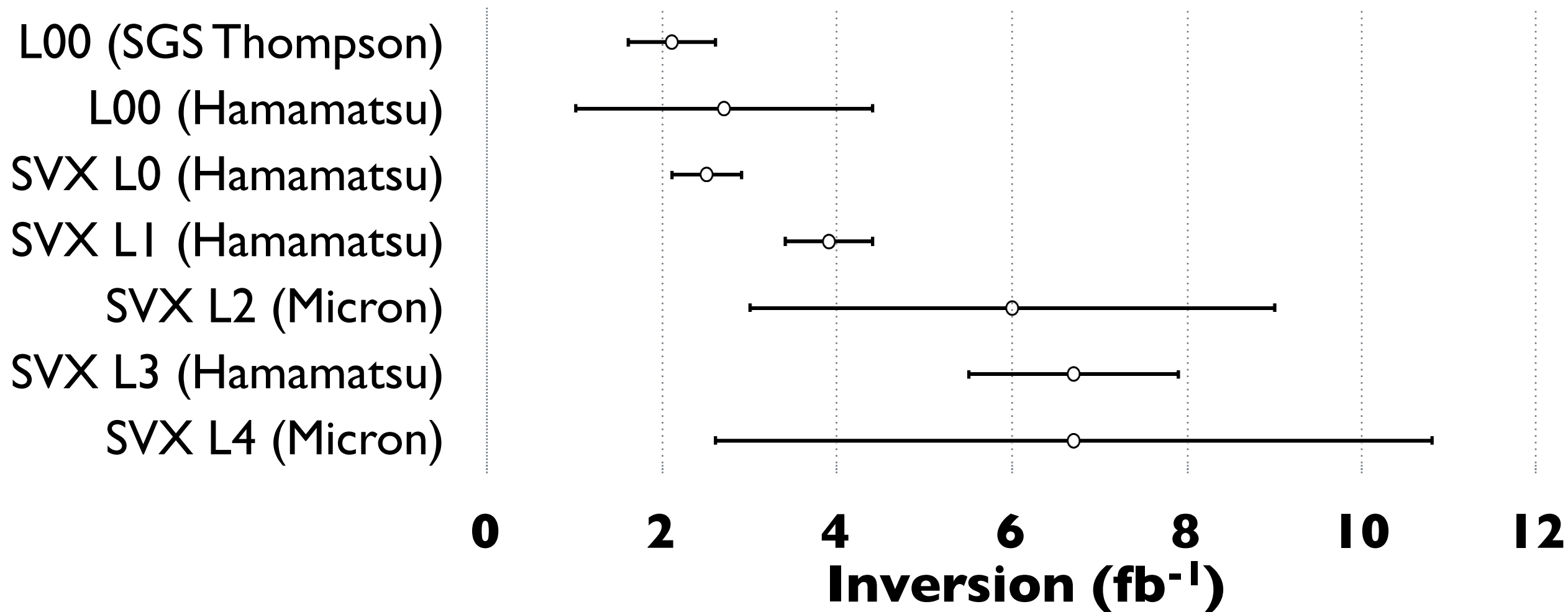
Shown are the mean and RMS of fit results for individual ladders

SVX Innermost Layer



prediction: S. Worm, "Lifetime of the CDF Run II Silicon," VERTEX 2003

Inversion Predictions

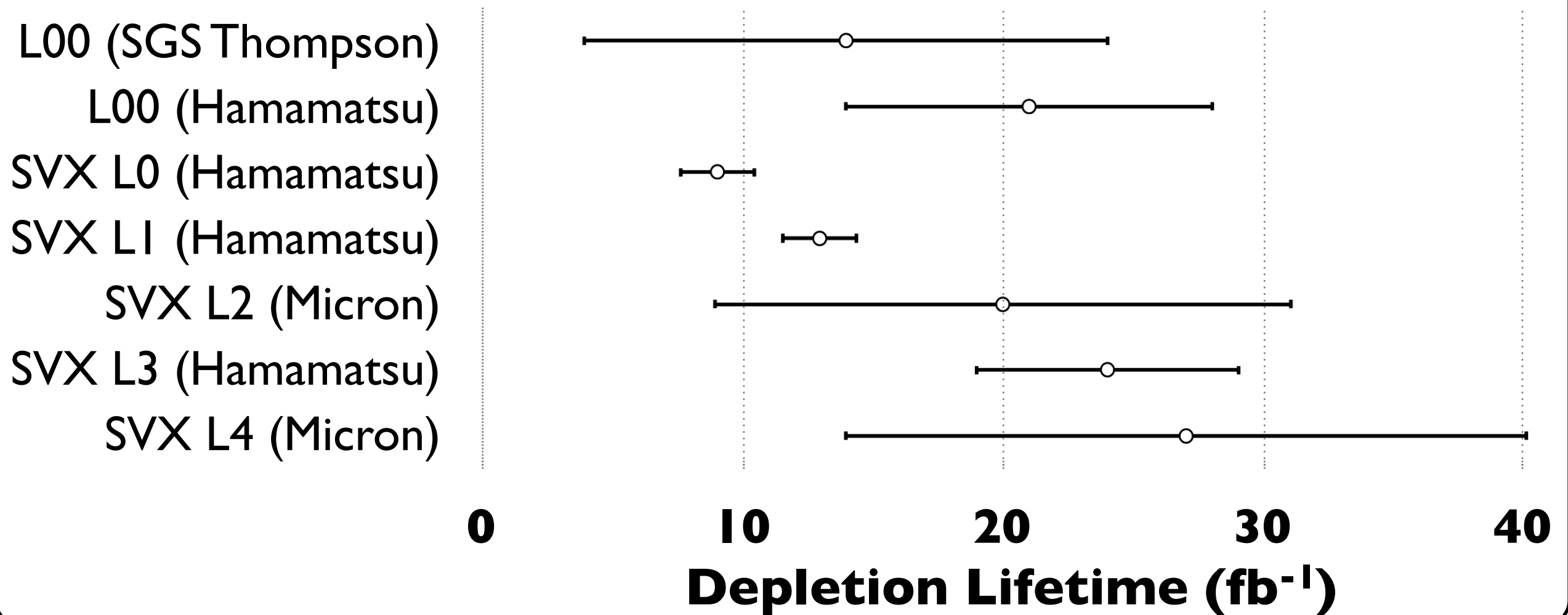


Shown are the mean and RMS of fit results for individual ladders

Depletion Lifetime Extrapolation

***Assuming the same slope after
inversion***

Depletion Lifetime Extrapolation



Assumes same slope after inversion

Summary

There are many factors affecting our silicon lifetime.

- ▶ We continue to study these issues with a broad effort.
- ▶ Depletion voltage is one of the chief suspects.

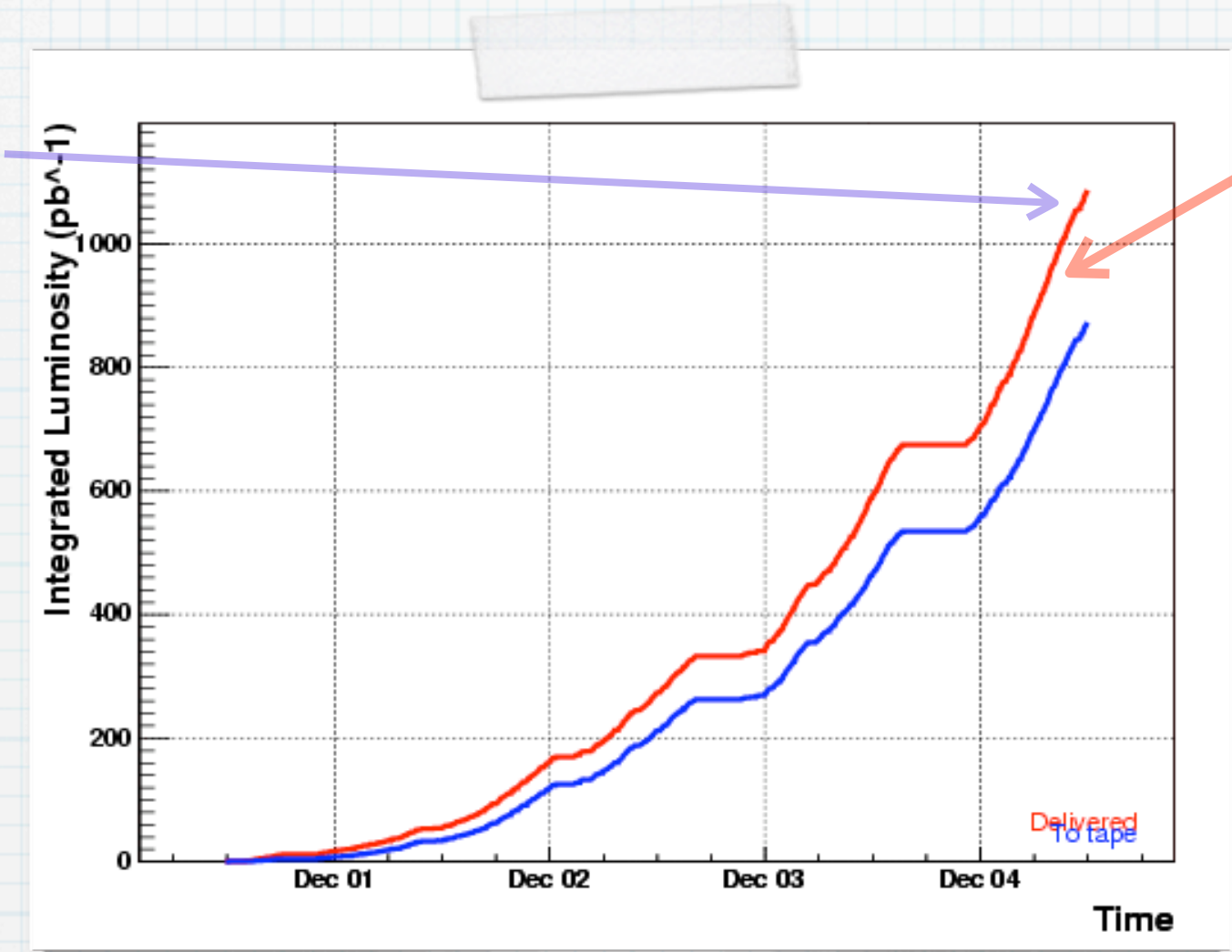
We are regularly monitoring the depletion voltage in our detector.

- ▶ Inner layers of SVX and L00 begin to invert in the next fb^{-1} .
- ▶ We have the necessary machinery to measure the slope after inversion.
- ▶ A same rate assumption suggests we should be able to deplete our silicon throughout Run II.

Additional Slides

Noise vs bias

7/3/05	1087/pb
2/11/05	776/pb
12/9/04	678/pb
8/19/04	672/pb
7/26/04	640/pb
6/17/04	560/pb
5/15/04	510/pb
1/12/04	357/pb
8/28/03	326/pb
8/1/03	301/pb
7/2/03	274/pb
3/9/03	180/pb



Signal vs bias

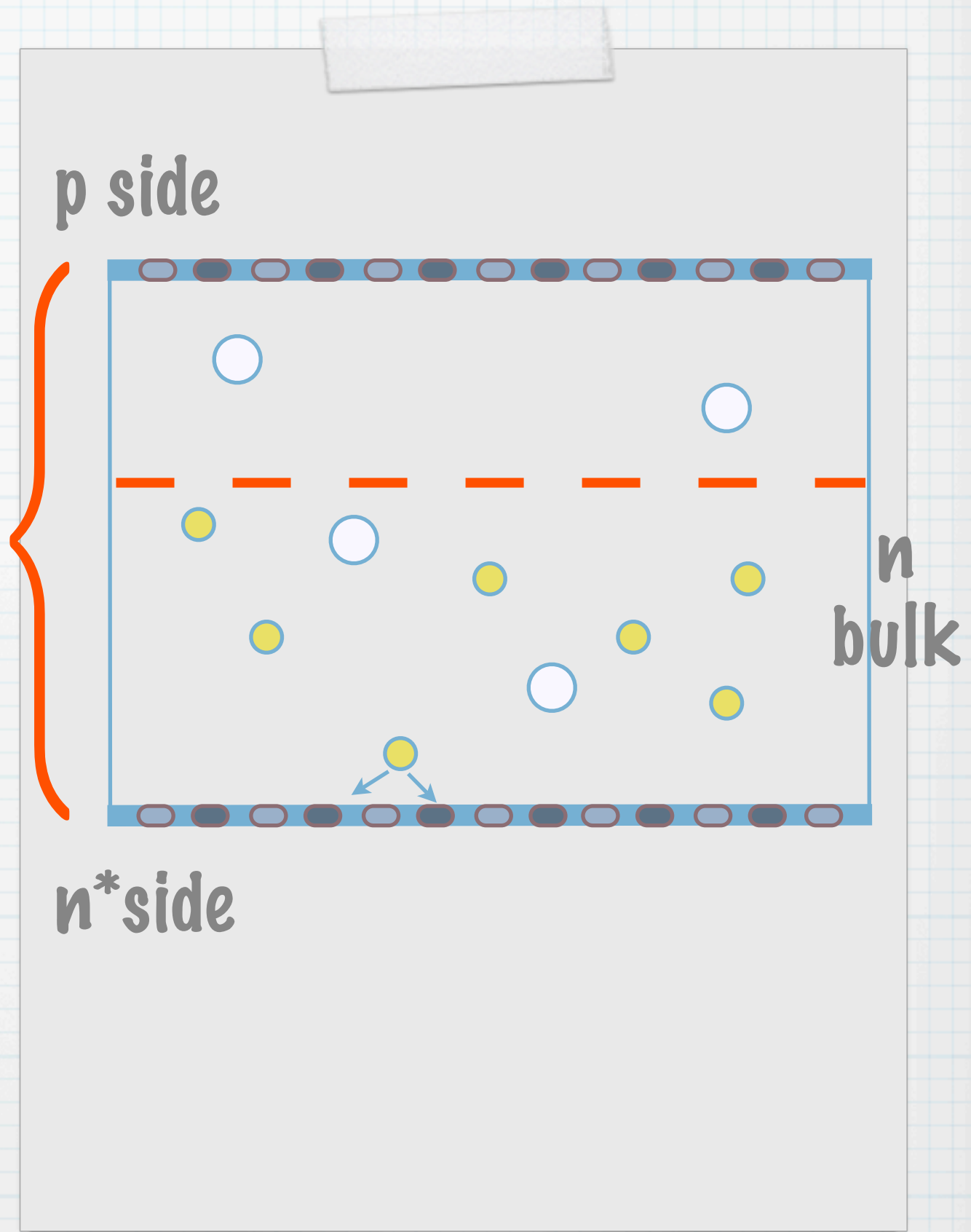
4/25/05	944/pb
7/29/04	646/pb
5/8/04	500/pb
2/8/04	394/pb
12/27/03*	341/pb
8/31/03	327/pb
5/22/03	241/pb

Scan History

Noise Method

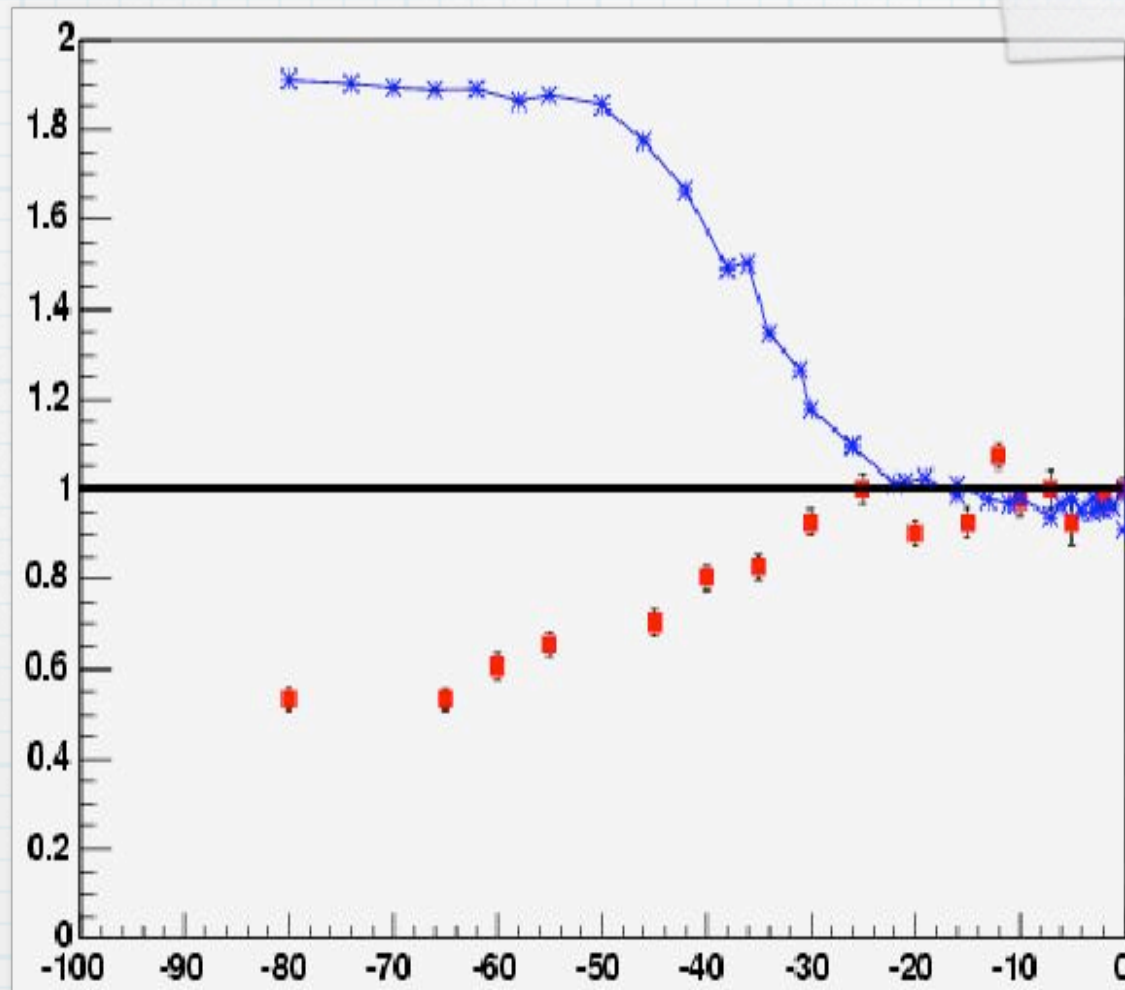
- thermal noise from free charge carriers
- bias voltage clears carriers from bulk
- depletes ϕ side first

V_{bias}

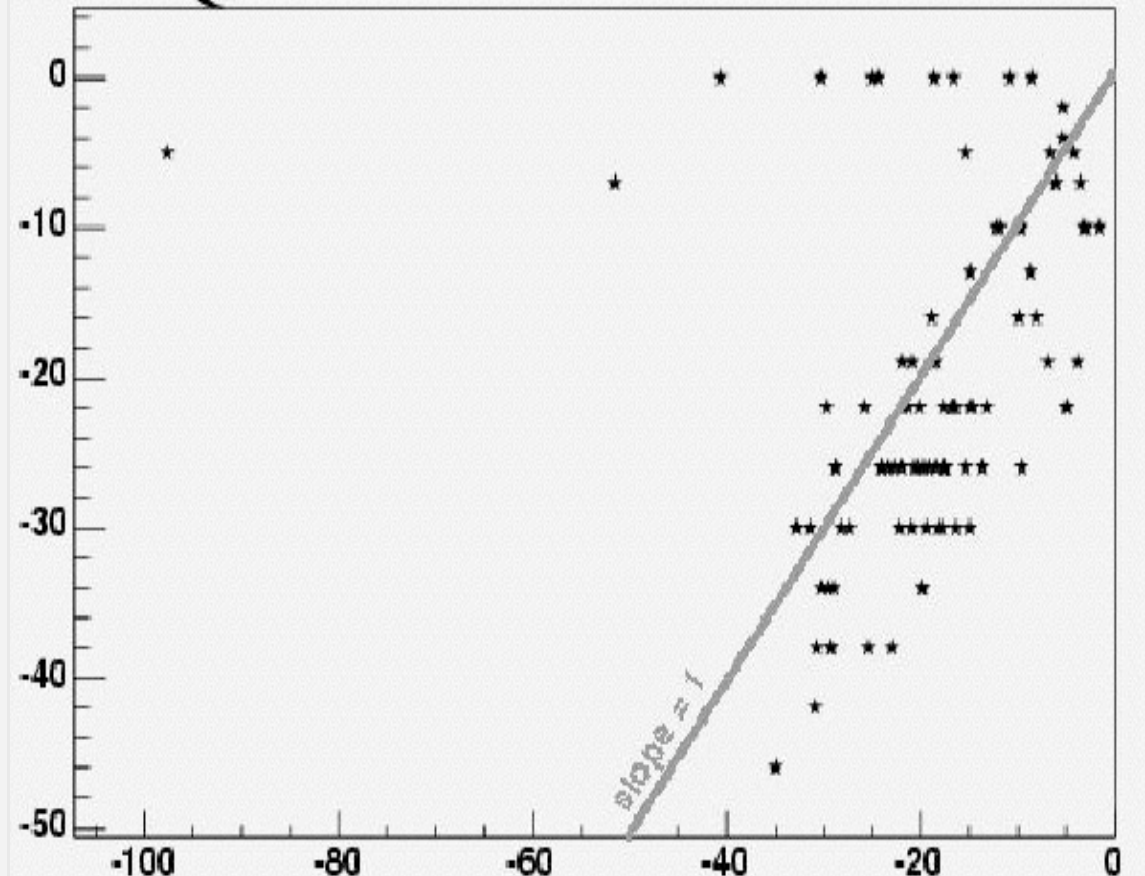


noise

Sept. '03



B1 Q method vs. Noise method



signal

- signal and noise methods correlated
- noise method does not sacrifice beam